

## **Nontarget Deposition of Methiocarb Applied to a Foliage Plant Staging Area**

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The tropical foliage industry comprises one of the fastest growing sectors of U.S. agriculture with a current wholesale value in excess of 663 million (ERS 2003). Florida continues to dominate the U.S. market by generating over 85 percent of foliage sales (Smith 1980; Minton et al. 2000; Hodges and Haydu 2002). The demands for foliage plants will likely increase throughout the developed world as consumers have more income available for such luxury consumption (Minton et al. 2000). As the demand for foliage plant production increases, opportunities for negatively impacting environmental resources may also increase due to management practices associated with this increased production. Pesticide applications are often necessary to produce high quality, high value ornamental crops. However, most common pesticide application practices result in placement on surrounding non-target ground surfaces. Deposition of pesticides on non-target surfaces results in material, labor, and financial wastes; and can inadvertently expose non-target organisms to the applied pesticide, either directly or indirectly through surface water runoff and/or drift.

Previous studies have shown that broadcast application of granular formulated pesticides can result in significant non-target losses due to pot spacing and plant growth form. Gilliam et al. (1992) reported non-target deposition of granular, broadcast applied herbicides to empty containers ranged from 23-30% when the containers were placed pot-to-pot, and increased to 79-80% when the containers were spaced on 30 cm centers. Mahnken and Sckroch (1992) reported higher herbicide concentrations (relative to per-pot applications) leaving simulated nursery sites that were treated by broadcast applications, and suggested that those higher concentrations were likely due to deposition of the herbicides on ground surfaces surrounding the pots. Numerous studies have reported losses of pesticides in nursery runoff water (Briggs et al. 2002; Briggs et al. 1998; Wilson et al. 1996; Wilson et al. 1995). In all of those studies, pesticide losses were greatest during runoff events that occurred shortly after application.

While some research has quantified non-target deposition of granular formulated pesticides in ornamental nurseries, little work is available on anticipated non-target deposition of spray-applied pesticides. At a given application rate, greater

deposition on non-target surfaces might be expected given the small droplet size and more uniform deposition patterns associated with spray application relative to granular materials.

The objective of this study was to characterize non-target deposition of a spray-applied pesticide under a variety of typical commercial shade-house nursery conditions using methiocarb as a surrogate.

## MATERIALS AND METHODS

This study was conducted at a commercial foliage plant nursery located in Fort Pierce, Florida. Four areas within the nursery were selected to evaluate deposition under two spraying scenarios, 1) spray application from one end for shorter rows (15.2 m), and 2) application from both sides for longer rows (21.9 m). These areas are normally used for staging plants before shipment out-of-state. Since plant architecture, size, and spacing influence non-target deposition, areas were chosen to include three different size classes of Weeping Fig (*Ficus benjamina* 'Monique') and one size of Lady Palm (*Rhapis excelsa*) for evaluation. The Weeping Fig categories included: small ficus (SF), medium ficus (MF), and large ficus (LF). Plant size classes and dimensions are listed in Table 1.

**Table 1.** Study area and plant dimensions (m) and mass (mg) of active ingredient applied.

Measurement	<i>Ficus benjamina</i> 'Monique'			<i>Rhapis excelsa</i>
	<u>Small</u>	<u>Medium</u>	<u>Large</u>	
Plant Height	1.09	1.73	1.98	0.7
Trunk Length	0.58	0.70	0.77	NM
Pot Height	0.24	0.33	0.38	0.34
Canopy Width	0.58	1.19	1.39	0.64
Pot Spacing	0.64	1.34	1.98	0.69
Aisle Width	0.41	0.87	0.43	0.3
Row Width	0.58	1.19	1.39	0.64
Aisle/Row Length	21.9	15.2	15.2	21.9
Aisle Surface Area (m <sup>2</sup> )*	8.98	13.22	6.54	6.57
Row Surface Area (m <sup>2</sup> )*	12.7	18.09	21.13	14.02
Total Surface Area (m <sup>2</sup> )*	21.68	31.31	27.66	20.59
AI Applied (Total-mg)**	5,228	5,439	4,805	4,964
AI Applied (Aisles-mg)**	2,164	2,297	1,135	1,584
AI Applied (Rows-mg)**	3,063	3,141	3,670	3,379

NM: Not measured due to bushiness and multiple trunk character of plants, but is approximately equal to plant height \*Divide total surface area by 4 to calculate surface area within each interval of targets. \*\*Calculated by multiplying [travel time to cover aisle or row width (s)] · [application rate (L·s<sup>-1</sup>)] · [890 mg-methiocarb · L<sup>-1</sup>-spray mixture].

The Weeping Figs were trained to a single trunk, while the Lady Palm (LP), a clustering-type palm, had multiple cane-like trunks/stems and palmate leaves with five to ten segments, divided almost to the base. All plants within each section were arranged in staggered rows. The LF and MF rows were 15.2 m long, and the SF and LP rows were 21.9 m long.

Methiocarb was chosen as a representative pesticide. It is the active ingredient in the commercial formulation of Mesurol® 75-W (Gowan; Yuma, AZ), an organophosphate insecticide, miticide, and molluscicide. The pesticide was mixed at a rate of 0.45 kg per 379 L of spray mixture. Applications were made using a PTO-driven Berthoud Super Puma 1000 canon airblast sprayer (Berthoud; Villefranche, France) calibrated to deliver 17.8 L of spray mixture per minute at a ground application speed of 0.1 m sec<sup>-1</sup>. Applications were made from the only accessible end of the shorter rows (MF and LF), and from both ends of the longer rows for the LP and SF areas.

Each aisle within the selected blocks was surrounded by a row of plants on either side. Three aisles and three adjacent plant rows were chosen within each block of plants. Non-target deposition was measured using 5.08 x 5.08 cm Teflon spray targets. Targets were fastened to 10 x 10 cm pieces of cardboard using staples. The cardboard provided structural rigidity to the targets, preventing them from curling up and blowing away as the sprayer passed. The teflon targets were placed at each end of the aisles, and at 5.5 m intervals between the two ends for the SF and LP areas; and at 3.8 m intervals for the MF and LF. Targets were also placed at the same distance intervals between the pots within an adjacent row on either side of the monitored aisle. Following application, each target was placed in a 70 ml polyethylene snap-cap vial, transported to the lab, and stored at -18°C until extracted and analyzed. Methiocarb was extracted from the targets by adding 10 ml of monochloroacetic acid buffer (pH 3) to each vial and vortexing each for two minutes. The containers were then sonicated for 15 minutes, followed by an additional 2 minutes of vortexing. The extracts were filtered through Millex (Millipore Corp; Bedford, MA) syringe-driven filters (0.22 µm), diluted 1:20 with monochloroacetic acid buffer, and analyzed using a Waters (Milford, MA) 2695 high pressure liquid chromatograph (HPLC) equipped with a Waters carbamate column, a post-column reaction module (PCRM), reagent managers, and a Waters 474 fluorescence detector. Operating conditions for the post-column reaction steps and a ternary gradient comprised of water, methanol, and acetonitrile were used as described in EPA Method 531.2 (Basset et al. 2001). Percent recoveries ranged from 98 to 103.

Total ground deposition along the length of each aisle-row unit was estimated by averaging adjacent concentrations and assuming that the calculated average concentration was representative of the deposition within that 3.8 or 5.5 m section of the aisle-row unit, depending on target spacing. The concentration was then multiplied by the surface area for each representative section (Table 1). The average deposition in each section was then summed to estimate total ground

deposition within the aisle-row units. Ground deposition was expressed in terms of the percentage of the total amount applied to each unit. The calculated total amount of methiocarb applied to each aisle-row unit based on the application rate was: 5,228 mg for SF; 4,964 mg for RP; 5,439 mg for MF; and 4,805 mg for LF.

Depositional data were analyzed to compare 1) differences between rows and aisles at each distance from the sprayer, 2) differences within rows and aisles with distance from sprayer, and 3) differences between species at each target location (MF vs. LF and SF vs. LP). In all cases, depositional data for the aisle and row target intervals were ranked and subjected to analysis of variance (ANOVA;  $P=0.05$ ). Means were separated by calculation of least significant differences. For the single-side applications (MF and LF), a linear regression analysis was also conducted to identify significant trends ( $P = 0.05$ ) in deposition with distance from the sprayer.

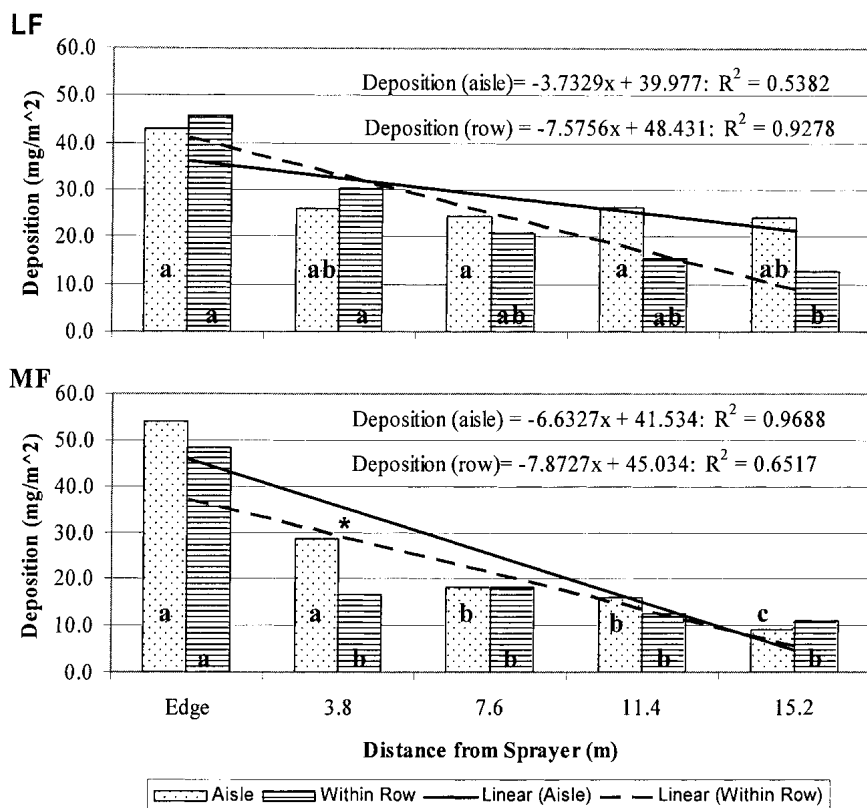
## RESULTS AND DISCUSSION

For the single-side spray, deposition on ground surfaces within the aisles and within the plant rows did not differ statistically at each respective distance from the sprayer for the LF application (Figure 1). Deposition for the LF application ranged from 24 to 43 mg m<sup>-2</sup> and 13 to 46 mg m<sup>-2</sup> within the aisles and rows, respectively. The only statistically significant difference in deposition with distance from the sprayer was observed within the row at the farthest target location (15.2 m), where deposition was approximately 72% lower than at the location closest to the sprayer. While differences in deposition with distance from the sprayer were insignificant for the majority of the target locations, there was a significant decreasing trend in deposition both within the aisles and within the rows (Figure 1). Within the aisle locations, deposition 3.8 to 15.2 m from the sprayer appeared to be relatively uniform, which might be expected given the lack of obstructing foliage.

Deposition at each respective target location within the aisles and rows for the MF application differed only at the 3.8 m distance from the sprayer (Figure 1). At this position, deposition within the row was 42% less than within the aisle. Deposition for the MF application ranged from 9 to 54 mg m<sup>-2</sup> in the aisles and 11 to 49 mg m<sup>-2</sup> within the plant rows, with the least deposition observed at the farthest targets.

While deposition within the aisles and rows did not differ statistically at most respective target locations, deposition with distance from the sprayer did. Within the aisles, deposition at 7.6 and 11.4 m from the sprayer was significantly lower than from the edge and at 3.8 m from the sprayer. Deposition at the farthest location (15.2 m) was significantly lower than at any of the other locations.

Within the plant rows, deposition from 3.8 m to the farthest location was statistically similar. A summary of the statistical analysis comparing deposition at



**Figure 1.** Deposition of methiocarb within aisles and plant rows for medium-sized ficus (MF) and large-sized ficus (LF). “\*” indicates statistical difference (ANOVA,  $P = 0.05$ ) between deposition in aisle and row at that location. Letters within bars may only be compared with similar-textured bars (i.e. within aisles only or rows only). Different letters indicate statistical differences ( $P = 0.05$ ) within that treatment (aisle or row), not between treatments.

each target interval between the LF and MF is shown in Table 2. Deposition at each location was similar between plant categories at each interval within the rows. Likewise, deposition within the aisles was similar between categories, except at the farthest target location (15.2 m), where deposition within the MF aisles was 50% less than in the LF.

A summary of the estimated total mass of active ingredient deposited within each section of the rows and aisles, as well as the total amount deposited, is shown in Table 3. As a percentage of the amount applied, deposition on ground surfaces within the aisles ranged from 13.6 to 15.9%; compared to 11.1 to 13.8% within the rows.

**Table 2.** Summary of statistical analysis comparing deposition at each target location between the plant categories.

<b>Single Side Application Deposition Study</b>					
<u>Comparison</u>	<u>Distance from Sprayer</u>				
	0	3.8	7.6	11.4	15.2
LF:MF (aisles)	NS	NS	NS	NS	*
LF:MF (rows)	NS	NS	NS	NS	NS
<b>Double Side Application Study</b>					
<u>Aisles</u>	<u>Distance from Sprayer</u>				
	North Edge	5.5(N)	11	5.5(S)	South Edge
SF:RP (aisles)	NS	NS	*	*	NS
SF:RP (rows)	NS	*	*	*	*

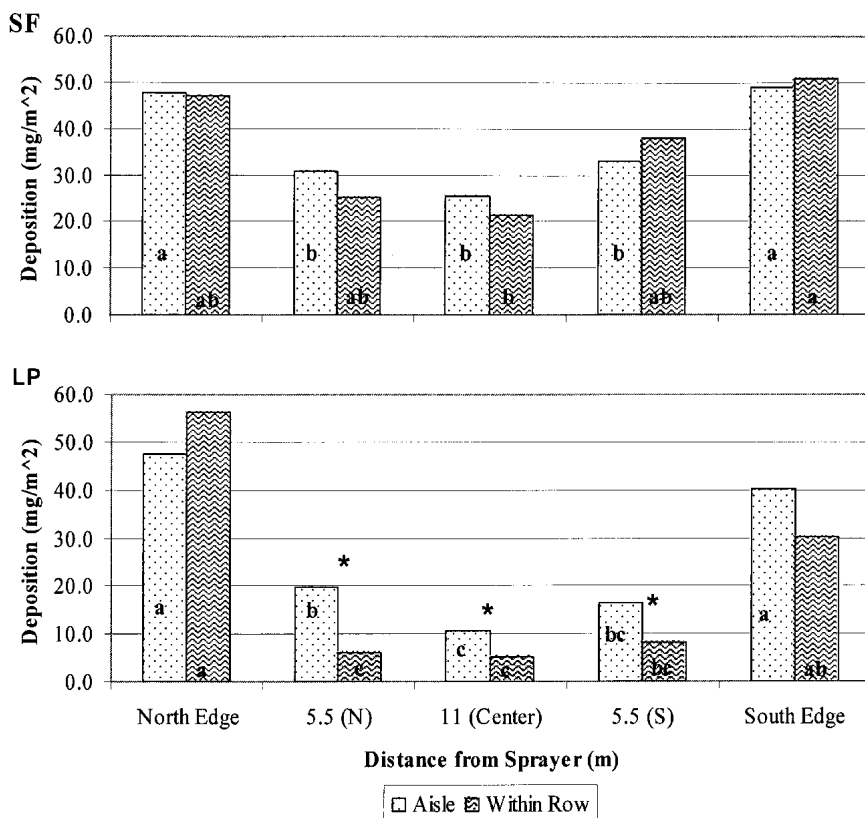
Refer to Figures 1 and 2 for corresponding data. \* Statistically significant difference; NS = not significant (ANOVA,  $P = 0.05$ ).

**Table 3.** Calculated mass (mg) of active ingredient (methiocarb) deposited on non-target ground surfaces during spray applications to medium- (MF) and large- (LF) sized Weeping Fig; and for small Weeping Fig (SF) and Lady Palm (LP).

<b>Plant/ Scenario</b>	<b>Distance Interval (m) within Row or Aisle</b>				<b>Total Deposition (mg)</b>	<b>% Applied</b>
	<u>0–3.8</u>	<u>3.8–7.6</u>	<u>7.6–11.4</u>	<u>11.4–15.2</u>		
MF (aisle)	136.6	77.4	57	41.7	312.7	13.6
MF (row)	147	78.9	69.9	53.6	349.4	11.1
LF (aisle)	56.3	41.1	41.5	41.3	180.2	15.9
LF (row)	200.9	134.4	95.6	74.9	505.9	13.8
<b>Plant/ Scenario</b>	<b>Distance Interval (m) within Row or Aisle</b>				<b>Total Deposition (mg)</b>	<b>% Applied</b>
	<u>NE– 5.6(N)</u>	<u>5.5(N)–11 (CTR)</u>	<u>11(CTR)– 5.5(S)</u>	<u>5.5(S)–SE</u>		
SF (aisle)	88.2	63.1	65.4	91.9	308.5	14.3
SF (row)	114.5	73.4	93.9	140.9	422.7	13.8
RP (aisle)	55.1	24.8	22.1	46.4	148.4	9.4
RP (row)	109.5	19.5	23.2	67.3	219.5	6.5

Note: NE = north edge, CTR = center, SE = south edge.

For the double-sided spray, no differences in deposition between rows and aisles were observed at each target interval for the SF (Figure 2). Deposition ranged from 25 to 49 mg m<sup>-2</sup> and 21 to 51 mg m<sup>-2</sup> for the aisles and rows, respectively (Figure 2). Within both the aisles and rows, deposition was greatest at the edges and decreased towards the center of the bed. Deposition within the aisles was significantly lower 5.5 m from the edges and at the center of the beds (11 m), ranging from 15 to 48 percent less than at the edges. Within the plant rows, deposition at the center of the beds was approximately 44 percent less than at the edges. In this case, deposition 5.5 m from both edges was statistically similar to the edges (Figure 2).



**Figure 2.** Deposition of methiocarb within aisles and plant rows for small-sized ficus (SF) and Lady Palm (LP). “\*” indicates statistical difference between deposition in aisle and row at that location. Letters within bars may only be compared with similar-textured bars (i.e. within aisles only or rows only). Different letters indicate statistical differences ( $P = 0.05$ ) within that treatment (aisle or row), not between treatments.

Contrary to results for SF, deposition in the rows and aisles at each respective distance for the LP application was statistically similar at the edges only, ranging from 30 to 56  $\text{mg m}^{-2}$ , respectively (Figure 2). Deposition 5.5 m from the edges and at the center of the beds was statistically lower within the rows than in the aisles, ranging from 11 to 20  $\text{mg m}^{-2}$  and 5 to 8  $\text{mg m}^{-2}$ , respectively. As with SF, methiocarb deposition on ground surfaces decreased with distance from the edges. Within the aisles, deposition 5.5 m from the edges and at the center was significantly lower than at the edges (Figure 2). Deposition within the plant rows was similar at the three center locations. Deposition (within rows) at 5.5 m from the southern end of the rows was also statistically similar to that seen at the southern edge. A summary of the statistical analysis comparing deposition at each target interval between the SF and LP is shown in Table 2. Significant

differences in deposition between species were apparent at each interval. Within the aisles, deposition in the center of the bed and at 5.5 m from the southern end was significantly lower for the LP than at the other locations, relative to SF. Deposition on ground surfaces with SF was from 1.25 to 3 times greater than LP. Within the rows, deposition at the northern end of the row did not differ between species. However, deposition at all other intervals within the row was significantly lower for the LP relative to SF. Deposition within the rows of SF at the 5.5 m and center locations was 2.6 to 7.6 times greater than in the LP block.

A summary of the estimated total mass of active ingredient deposited within each section of the rows and aisles, as well as the total amount deposited, is shown in Table 3. As a percentage of the amount applied, deposition on ground surfaces within the aisles ranged from 9.4 to 14.3%; compared to 6.5 to 13.8% within the rows. Within both the aisles and rows, deposition was lower on LP ground surfaces, which is likely explained by the increased coverage of ground surfaces by the foliage.

Results from this study indicate that from 15.9 to 29.7% of the applied pesticidal active ingredient may be deposited on non-target ground surfaces within typical foliage nursery situations. Deposition was generally greater in aisles that were not covered by foliage. These results also demonstrated the significant differences in deposition that might be expected due to differing plant forms. While this study focused only on methiocarb, the results may also be applicable for any other pesticide that is spray-applied using an air-cannon type of sprayer.

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